REMARKS

In order to emphasize the patentable distinctions of applicants' invention over the prior art, claim 1 (as well as claims 2-9, dependent thereon) and claim 11 (as well as claims 12 and 13, dependent thereon) have been amended to recite that the previously cast amorphous metal alloy strip is permanently deformed to form an articulated topographical definition possessing a relaxed stress state and representative deformation features such as slip lines or shear bands. These slip lines or shear bands are present in the articulated definition features. They are inherently absent in an 'as-cast' amorphous strip. Free flow of molten metal into a depression or protuberance in a chill wheel does not result in shear bands in the solidified amorphous strip because the molten metal is brought into the shape provided in the chill wheel before any solidification occurs. As a result, the solidified as-cast strip bearing the depression or protuberance is free from any deformation of the solidified amorphous ribbon and does not display shear bands in these regions. The internal stresses in a permanently deformed strip essentially arise from solidification of different portions of a complex shape, such as depression or protuberance at different time periods. As a result, the depression or protuberance may appear puckered or lack planar face. Claims 1 and 11, as amended, additionally recite that selected forces to which the 'as cast' amorphous metal strip is subjected are applied using a set of stamping dies having matching surfaces that induce permanent deformation at a selected process temperature to produce a shape or configuration that is selected; that the permanent deformation results in articulated topographical definition of any selected shape or configuration

distending at a depth greater than the strip thickness; and that the deformation is conducted at a selected temperature without strip embrittelement or crystallization.

The stress relaxed state of the deformed ribbon with articulations is clearly defined in the original specification. Successful practice of the present invention relies upon the exploitation of stress relaxation characteristics of the amorphous metal alloy. "Stress relaxation in amorphous metal alloys is intimately linked to atomic structure relaxation, in which the "free volume" which is quenched-in during production is gradually dissipated while a test piece undergoes a shape change, such as the development of geometrically articulated including patterns, textures or other definitions. The greater the free volume content of an amorphous metal alloy, the greater its ability to take on geometric definition during processing. Figure 1 shows the time-temperature dependence of stress relaxation for an amorphous metal alloy having nominal composition $Fe_{80}B_{11}Si_9$." (Page 5 lines 8-16).

In light of the requirement listed under item (i) above there are no restrictions on the wall angle or the angle between the edges of the articulated topological definition and the permanently deformed amorphous metal strip length direction. The thickness of the strip is maintained in the flat plateau portions 28 of the articulation (as shown in figure 2B of the drawings) since this portion is not stretched when pressed using a stamping die. However, the sides of the articulation are extended and stretched by application of selected forces. Such selected forces are imparted by a set of stamping dies, the mating surfaces of which induce the permanent deformation at a selected process temperature. When thus processed, the sides of the articulation have a thickness generally smaller than that of the original strip. The corners of the articulated topographical definition are smooth and the strip thickness at these locations is equal to or smaller than that of the original strip thickness,

allowing stackability of these strips with articulated topological definition. This distended condition of the strip is shown in Figs. 2-4 of the drawings. The articulated topological definition may be periodic or random and may have shapes including hexagonal, rectangular, circular or pyramidal configurations with no special restriction on wall angles or orientation of the articulated topological definition with respect to the length direction of the permanently deformed amorphous metal strip.

Claim 11 (and claims 12-13 dependent thereon) have been amended to recite (i) that the article comprises a plurality of self-nesting permanently deformed stress relaxed amorphous metal alloy strips; (ii) that each of the strips is a generally planar, previously cast amorphous metal strip; (iii) that each strip has an articulated topographical definition shape exhibiting shear bands in said articulated definition distending at a depth greater than the strip thickness; (iv) that the articulated topographical definition is produced on each of the strips by application of selected forces imparted by a set of stamping dies having mating surfaces at a selected process temperature; and (v) that application of the selected forces induces permanent deformation of a shape or configuration distending at a depth greater than the strip thickness (iv) the edges of articulated topographical definition are free from enhanced strip thickness and the deformation is conducted at a temperature without strip embrittlement or crystallization. Each of these amendments is clearly supported by the original specification.

As pointed out by the original specification, the articulated topographical definitions are permanently deformed into a generally planar ("2-dimensonal") amorphous metal strip or ribbon by the application of selected forces at a selected process temperature so to produce a non-planar ("3-dimensional") amorphous metal strip or ribbon which includes a geometric pattern, texture, profile or other feature, collectively referred to as "articulated topographical definitions". The original

specification in page 4 lines 24-28 details this permanent deformation of an 'as-cast' amorphous strip. 'With respect to such articulated topographical definitions, it is required only that there be introduced permanent deformations which will distort or distend the generally planar amorphous metal foil or ribbon, as is usually applied in an "as cast" form, so to provide a permanent non-planar three-dimensional profile'. With respect to such articulated topographical definitions, it is required only that there be introduced permanent deformations imparted by a set of stamping dies having mating surfaces at selected process temperature which will distort or distend the generally planar amorphous metal strip or ribbon, as is usually applied in an "as cast" form, so to provide a permanent non-planar three-dimensional profile. Since the planar ribbon which may have internal stresses is exposed to this deformation temperature, all internal stresses are relieved. The deformation producing a depression or protuberance is made possible by shear bands that do not result in internal stresses. The specification also teaches that the geometrically repeating articulated topographical definitions can be any shape or configuration which provides a regularly repeating pattern of articulated topographical definitions, and ideally are those shapes or configurations which show an interlock between their individual patterns, due to smooth corners and the absence of enhanced strip thickness at the corners of articulated topographical definition. The specification also teaches random articulated topographical definitions as shown in figure 3a and page 7 lines 18-21. Further, the specification discloses that the selection of an appropriate deformation temperature is to be based on the considerations of minimizing or eliminating crystallization during the stamping step, and ideally also based on the considerations of minimizing or eliminating embrittlement of the amorphous metal strip during this stamping step. At these temperatures permanent deformation

results in inhomogeneous plastic flow resulting in shear bands in the articulated topographical definition region.

The original specification teaches that the permanent deformation is produced by plastic deformation processes in page 2 line 24 - page 3 line 12. 'When subjected to sufficiently high mechanical stress, amorphous metal alloys undergo heterogeneous plastic deformation through the formation of highly localized shear bands, at temperatures well below the glass transition temperature, T_g. This type of heterogeneous plastic deformation is similar to that of conventional crystalline alloys'. 'In contrast, the mode of plastic deformation near and above T_g is one in which the macroscopic strain in the specimen results from homogeneous deformation by viscous-like flow throughout the entire sample volume'. 'Patterson et al. in Rapidly Quenched Metals III, vol.2 (1978) describes the ability to hot form amorphous metal alloy ribbon into a cup-like shape when deformed at elevated temperature. The authors teach an appreciation for the trade-off between hot forming temperature and time, and the risk of amorphous metal alloy crystallization when process temperature is too high'.

The original specification page 9 lines 13-22 clearly points out that the temperature at which the plastic deformation is carried out is a critical factor. With regard to the temperature at which the stamping process occurs, applicants have discovered that while a higher elevated temperature typically results in a shorter residence time in the die, or alternately less pressure required of the die, such elevated temperature is not desired where there is a significant risk of crystallization and/or of embrittlement of the amorphous metal alloy foil or strip. In these higher elevated temperature processing conditions, the plastic deformation mode is homogenous and is devoid of heterogeneous plastic deformation features such as shear bands. <u>The process for creating</u>

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articulated topographical definition in the subject invention uses a temperature wherein heterogeneous plastic deformation occurs with characteristic shear band features in the articulated topographical definition region.

The protrusions and depressions are large, as compared to the strip thickness and can have a selected shape or configuration (see also Figs. 2-4). The original specification teaches shapes selected from a group of shapes consisting of hexagonal, rectangular, circular or pyramidal configurations and others (page 5 lines 3-7). Advantageously, owing to the presence of smooth corners and an absence of enhanced thickness at the corners of articulated topographical definitions, the protrusions nest or interlock with depressions of an adjoining strip to create laminations. This relationship is discussed at page 4, line 9 of the specification. In addition, the tips of the protrusions of a plastically deformed flat sheet can be lopped off. With this arrangement, there is created a cutting edge for an abrading tool (see page 11 line 29 of the specification). These protrusions and depressions are typically created by subjecting a previously cast planar sheet of cast amorphous metal to plastic deformation forces provided by a male/female die set. (See page 15, lines 13-21 of the specification). The restriction “of a shape or configuration distending" and "without strip embrittelement or crystallization" is fully supported by page 5, line 1 and page 8 lines 22-29, of the original specification. Such articulated topographical definitions are created by the application of selected forces to a generally planar (2-dimensonal) amorphous metal foil or ribbon. These selected forces at selected process temperature induce permanent deformations in the ribbon that produce a non-planar (3-dimensional) amorphous metal strip or ribbon. Such deformations can include a geometric pattern, texture, profile or other feature, collectively referred to as “articulated topographical definitions”. With respect to such articulated topographical definitions, it is required

only that there be introduced permanent deformations which will distort or distend the generally planar, previously cast amorphous metal foil or ribbon to provide a permanent non-planar three-dimensional profile.

There are significant advantages to creating permanently deformed "articulated topological definition" by permanent deformation of a flat, previously cast sheet in the "as cast" condition, as compared to casting an "articulated topological definition" article by free flow of molten metal into articulations contained by the chill wheel, as disclosed by Narasimhan. Since the melt freely flows into articulations of the chill wheel, the solidified strip takes this form without any plastic deformation. As a result, no shear bands are seen in these articulated regions in the Narasimhan strip. The 'as-cast' Narasimhan product does not have the structural features of shear bands or slip lines that are always present in the material produced by the subject invention, which permanently deforms an 'as-cast' amorphous metal strip at a sufficiently low temperature to create shear bands and thereby avoid embrittlement or crystallization.

Narasimhan's process relies on creating a casting geometry wherein a thin uniform layer of molten metal is mechanically supported on a contoured chill surface within the 'gap region' by use of a slotted nozzle which is in communication with a molten metal reservoir. The slotted nozzle is defined by a pair of generally parallel lips, a first lip and a second lip, numbered in direction of movement of the chill surface, and is positioned above the contoured chill surface at a specified gap. A pressurization means effects expulsion of the molten metal from the reservoir through the nozzle onto the moving chill surface filling the 'gap' region with molten metal and the pressurization is selected so that the melt does not spill beyond the slotted nozzle. The presence of a contoured definition on the chill surface effectively enhances the gap locally, but the pressurization is

sufficient to fill this enhanced gap region with the melt effectively. Mechanical support of the melt in this casting geometry is not compromised. Solidification is controlled by the extraction of heat from the molten metal and the thickness of the ribbon solidified is approximately the same on the flat regions and articulated regions. At the corners of articulation more heat is extracted due to increased area of contact of molten metal with the chill surface and results in a thicker ribbon at the corners. All protrusions in the strip do not experience the same enhancement in the thickness due to (i) variable contact between chill surface at the strip corner and the melt; and (ii) entrapment of an air boundary layer between the chill surface at the corner and the melt. This is expected at the corners of waffles (shown in figure 8 of Narasimhan patent). As a result, strips produced using the Narasimhan process are not generally stackable without leaving a large gap between individual strips forming a laminate. Laminations having this geometry lack the stacking factor needed to produce high quality magnetic laminations. If a strip produced in accordance with the Narasimhan process were to be machined to produce an abrasive tool by cutting off the tip of the protrusions on the as-cast strip, extra depth would have to be removed to eliminate the enhanced thickness at the corners. Moreover, with such a strip, sharp edges would not be easily obtained due to the unevenness of filling of the corners at each protrusion.

Specifically, Narasimhan uses a casting chill or casting belt substrate, each of which has depressions that are replicated by the cast strip. There are serious limitations to the inclination of the protrusions or depressions with respect to strip length and the wall angles of protrusions created by the Narasimhan casting process, especially when the thickness of protrusions or depressions is greater than the thickness of the strip. The inclination of the protrusion or depressions with respect to the length direction of the as-cast amorphous strip has a strong effect on the ability to fill the gap

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with molten metal under applied pressurization. A protrusion or depression that is perpendicular to the length direction of the as-cast amorphous strip results in a spilling effect and compromises the ability to fill the gap region resulting in discontinuous strips. The problem of melt filling is decreased as the angle of protrusion or depression deviates from this perpendicularity. Correspondingly, there is a stronger restriction on the wall angle to 65 degrees when the protrusion or depression has a feature that is perpendicular to the strip length direction and the wall angle is increased to 88 degrees when the protrusion or depression is parallel to the strip length direction. Thus, the angles of the Narasimhan protrusions are more restricted, being less than 65 degrees wall angle, and preferably less than 60 degrees, when the walls are transverse to the casting direction (see col.1, lines 66-68 and col. 3, line 21 of Narasimhan). When these angular relationships are not adhered to within a 2-degree range, the protrusions do not attach to the base strip (col. 2, line 16). Therefore it is virtually impossible to produce waffle patterns having equal wall inclination angles unless the inclinations are less than 65 degrees, and preferably less than 60 degrees. This requirement imposes a severe limitation on the number of protrusions that can be placed side by side. In addition, these strips have enhanced ribbon thickness at the corners of the waffles, resulting in poor stacking of laminations. If these wall angles are deviated, the protrusions may be disconnected from the base strip as indicated at col. 2, lines 13-17. When protrusions are disconnected to the base strip, the Narasimhan product does not effectively function as an abrasive, since the protrusions tend to tear and fold over. In addition, the patterns produced by the direct casting process of Narasimhan have an inherent periodicity, which is the circumference of the chill surface; this is the case whether the chill surface is a quench-wheel or a casting belt. Arbitrary shapes, including non-periodic structures or articulations, the depressions of which have wall angle

greater than 65 degrees on all sides, cannot be produced by the Narasimhan process. For the case of small wall thickness angles, the protrusions are inherently spaced further apart, and the number of protrusions available in an abrasive article produced by the Narasimhan direct casting process is severely reduced. On the other hand, protrusions formed by permanent deformation, as called for by applicants' claims, can have any shape or configuration without any restriction on wall angles, spacing or periodicity. Unlike the Narasimhan process, permanently deformed amorphous metal alloy strip called for by applicants' claims has a strip thickness that is precisely preserved without any discontinuity of the protrusions at the strip base plane. It is therefore submitted that the product called for by applicants' claims has substantially different geometric features than those disclosed by Narasimhan.

There also exist significant magnetic property differences as a consequence of plastic flow during permanent deformation. Narasimhan's process uses a liquid metal that flows freely into depressions or protrusions provided on the chill surface. This free flow of molten liquid metal is not deformation by force, as suggested by the Examiner. Molten metal naturally takes the shape of any containment provided, which is the gap region; this is a fundamental property of a liquid. The melt simply resides and is made available in the gap region and the solidification process creates the amorphous strip. There is no pressure applied to create a shape in the amorphous metal, rather it is simply solidified and taken away by the chill surface movement. On the other hand, permanent deformation of a previously cast, amorphous metal sheet is readily carried out at markedly different temperatures. Plastic permanent deformation results in shear bands along which easy magnetization occurs. The "articulated topological definition" is greater than the thickness of the strip, so that magnetic domains align along the shear bands. This alignment is discussed in Amorphous Metallic

Alloys, Edited by F.E. Luborsky, Pub. Butterworths, 1983, pages 313-314; see, in particular, the section entitled "Roll-Induced Anisotropy". A copy of the "Roll-Induced Anisotropy" chapter has been provided with applicants' April 3, 2003 amendment. The roll-induced anisotropy is essentially the same as the permanent deformation produced by stamping dies, wherein plastic deformation creates shear bands within the amorphous strip. Plastic deformation effected during rolling as well as stamping is well known. In roll deformation, the shear bands are restricted to a specified depth from both sides of the strip being rolled, while the shear bands occupy almost the entire thickness of the strip during a stamping operation, especially along the edges of the strip which is being stretched and the corners of the articulated topographical definition. The magnetic property of the strip is controlled by these slip lines or shear bands, which may hinder the movement of magnetic domain walls, decrease the permeability of the material, and degrade its soft magnetic properties. Clearly, the magnetic properties of the as-cast Narasimhan product are very different from those afforded by permanently deformed, previously cast strip having "articulated topological definition", as called for by applicants' amended claims 1-9 and 11-13. The effect of shear bands on the hardness and other mechanical properties of applicants' claimed strip is minimal.

More specifically, the product of claims 1-9 and 11-13, as amended, is restricted to permanent deformation of a previously produced strip in accordance with a particular process resulting in stress free articulated ribbons that exhibit shear bands in the articulated region. That process requires the preparation of geometrically articulated amorphous alloys having a shape or configuration produced by applying force imparted by a set of stamping dies having mating surfaces to permanently deform a previously cast planar, amorphous metal sheet with depressions and protrusions greater than the strip thickness at a selected process temperature without embrittelement

or crystallization. It does not include products wherein the articulations are produced by direct quenching from a melt with no permanent deformation of the strip. The products, which result from application of selected forces imparted by a set of stamping dies having mating surfaces to induce permanent deformation, produce 3-dimensional shapes in a previously cast, generally planar 2-dimensional ribbon. These geometrically articulated amorphous metal shapes show shear bands all over the articulated topological features and are structurally relaxed due to the absence of directional thermal contraction stresses inherent in an 'as-cast' amorphous metal strip. As a result, the geometrically articulated amorphous metal shapes are endowed with superior mechanical properties, including exceptional cutting capability and excellent magnetic properties. On the other hand, quenched products of the type produced by Narasimhan, which are said to have geometrical articulation, are in an un-relaxed state, as shown in Fig. 1 of the specification. They do not possess superior magnetic properties or cutting properties, since internal stresses are additive to applied cutting stresses. The magnetic and mechanical properties of applicants' claimed geometrically articulated amorphous strip, which is produced by mechanical forming processes, are superior to properties produced by direct quench methods. In addition, the Narasimhan process for direct casting of angular articulation, similar to hexagonal geometrical articulation, as shown in Fig. 2A, generally results in poor reproduction due to (i) melt accumulation along angular edges and wall angle, and (ii) wall orientation with respect to strip casting direction. This melt accumulation behavior, as well as the poor reproduction of the pattern, is acknowledged by USP 4,322,848 to Narasimhan (see col. 1, line 60 through col. 2, line 17). By way of contrast, the permanent deformation process used to modify a previously cast strip and thereby produce the geometrically articulated strip of applicants' claims does not have any of these limitations, since the metallic glass

essentially flows along the shape of the die. Moreover, non-periodic structures cannot be produced by the Narasimhan process, since the geometrically articulated amorphous metal invariably has a periodicity, created by the circumference of a quench wheel or belt. Clearly, the permanent deformation of a previously cast amorphous metal strip to create geometrically articulated amorphous metal alloys affords definitive advantages upon which patentability can be predicated.

Claims 1-4 and 6-9 are rejected under 35 U.S.C. 103(a) as obvious over Narasimhan (U.S. Patent 4,332,848).

The Examiner has taken the position that Narasimhan discloses glassy metal strips having a composition within the limitations of instant claim 4 and which contain a repeating geometrical pattern of structurally defined protuberances and/or indentations. In addition, the Examiner has stated that the preferred depth in Narasimhan is as much as 10 times the thickness of the strip; see Narasimhan column 7, line 60. The Examiner has stated that this same paragraph of Narasimhan defines a structure consistent with the presently claimed "selected shape or configuration distending". With respect to claims 6-9 the Examiner's position is that the suitability of a material for abrasive or cutting purposes is directly related to its composition, shape, and relative hardness compared to the material being abraded or cut. Because all of these parameters are the same in the prior art or the claimed invention, the Examiner's position is that the claimed limitations are inherent in the Narasimhan material.

The Examiner has also stated that Narasimhan does not state that the prior art material is "previously cast", that it was subjected to "application of selected forces imparted by a set of stamping dies having mating surfaces", and does not specify the negative limitation of "without strip

embrittelement [sic] or crystallization". These differences are not seen as resulting in a patentable distinction between the prior art and the claimed invention because

a) The limitations regarding previously cast material and application of forces imply a difference in the process by which the claimed products are made, as opposed to any difference between the actual claimed products and those of Narasimhan. It is well settled that a product- by-process claim defines a product, and that when the prior art discloses a product substantially the same as that being claimed, differing only in the manner by which it is made, the burden falls to applicant to show that any process steps associated therewith result in a product materially different from that disclosed in the prior art. See In re Brown (173 USPQ 685) and In re Fessman (180 USPQ 524). In the present case, Applicant has not met this burden, and the claimed products are held to be at best obvious variants of those disclosed by Narasimhan.

b) With regard to a material without strip embrittlement, no specific amount of this embrittlement is either defined or excluded by the instant claims, and whatever amount may or may not be present in the Narasimhan materials would fall within the presently claimed limitations. As to crystallization, the Narasimhan disclosure is drawn to the production of glassy or amorphous materials. It is thus a reasonable assumption that the prior art materials lack any substantial amount of crystallization.

Consequently, the examiner states that a prima facie case of obviousness is established between the disclosure of Narasimhan and the invention as presently claimed.

These statements of the Examiner are respectfully traversed. There are strong differences between the geometrically articulated 'as cast' amorphous material and that created by permanent deformation produced by application of selected forces imparted by a set of stamping dies having

mating surfaces according to the subject invention. The permanently deformed amorphous strips show shear bands in the areas of deformation such as depressions and protuberances , which can be readily observed. In the process disclosed by USP 4,332,848 to Narasimhan, the chill wheel or belt is designed so that the melt can flow and replicate the wheel's shape during casting (see col. 1, lines 60 through col. 2 line 17). Since the melt flows freely replicating the articulated definition, these as-cast amorphous ribbons <u>do not have any shear bands that are observable since, during melt flow filling the depressions or protuberances, the strip has not yet been formed or deformed in any manner</u>. In that process, quench wheel depressions have different casting velocities due to wheel radius reductions at the locations of the depressions. This causes the geometrically articulated amorphous material to have a permanent curvature akin to that of the chill wheel. If the geometrically articulated ribbons are straightened by application of force, the ribbon tears or flattens out at these geometrical articulations. Casting on a belt may, in certain cases, be devoid of these problems, which result from casting at different velocities. However, in such cases the belt would need to be extraordinarily thick to accommodate the chill surface depressions. Moreover, for such cases, the driving wheels for the belt would need to be extraordinarily large, making the process highly impracticable. As a matter of fact, all amorphous strips are presently produced on a quench wheel, and not on a belt of any kind, owing to troublesome problems encountered when driving a thick belt, and problems created by fatigue of the belt surface due to thermal loading and repeated bending action. Thus, as a practical matter, non-periodic geometrical articulation cannot be produced by the quenching process, since the quench surface is periodically brought under the casting nozzle. The 'as-cast' ribbons have trapped internal stresses induced during quenching. Such stresses are thermal contraction stresses that have different values along different directions of the

ribbon. Mechanical properties of the ribbons are correspondingly reduced due to the additive nature of the internal stresses with applied stresses. In addition the magnetic properties are reduced owing to these internal stresses, since most magnetic alloys are magnetostrictive. There are severe restrictions on the wall angle of protrusions created during direct quenching with the Narasimhan process. Such protrusions are nominally restricted to 65 degrees, and preferably less than 60 degrees, to the strip basal surface, when the protrusions are larger than the strip thickness. Use of small wall angles results in larger spacing between protuberances, decreasing the number of cutting elements in an abrasive strip. Additionally, as previously noted, a strip produced by the Narasimhan direct casting process is much more likely to contain discontinuities between the protrusions and the strip surface, especially when the wall angle is slightly larger than 65 degrees by even as little as 2 degrees. Due to the enhanced cooling provided at the corners of geometrical articulation, the strip thickness is increased, thereby resulting in strips that are not readily stackable. These protrusions cannot be readily machined off to create an abrasive article since the thickness enhancement at the corners need not be exactly equal at all protrusions due to differences in melt- chill surface contact as well as entrapment of an air boundary layer between chill surface and the melt being quenched.

The geometrically articulated permanently deformed amorphous metal strip defined by applicants' claims 1-4 and 6-9, as amended, is clearly identifiable from an as-cast strip. Unlike an as-cast strip, the geometrically articulated strip of applicants' claims 1-4 and 6-9, as amended, exhibits (i) <u>permanently deformed</u> stress free amorphous metal strip with characteristic shear bands or slip lines visible in the deformed regions of articulated regions, (ii) an absence of internal stresses; (iii) superior magnetic properties; (iv) non-periodic as well as periodic geometrical articulations of a selected shape or configuration produced by the application of selected forces,

which are imparted by a set of stamping dies having mating surfaces; (v) preservation of strip flatness; and (vi) no restrictions on wall angle or orientation of the articulations. Significantly, the geometrical articulations called for by applicants' claims are much larger structures, having a thickness greater than the thickness of the amorphous ribbon (see, for example, Fig. 2B, 3B and 4 of applicants' specification).

Narasimhan uses grooves or indentations in the casting wheel to cast a sheet of planar flow cast strip, which has protrusions on one side and corresponding indentations on the other side. Since the depressions in the casting wheel translate at a reduced casting speed, these amorphous sheets with three-dimensional character cannot be laid flat or stacked in any manner to produce a usable stack. Belt cast amorphous sheets might not have these differential velocity problems; but belt casting is not presently used, even in laboratory set-ups, due to severe problems of belt fracture, owing to belt fatigue caused by thermal stresses and repeated bending. It is respectfully submitted that the presence of any indentations in the chill surface of a belt would markedly exasperate these belt fatigue problems. By way of contrast, the strip defined by applicants' claims produces these "articulated topological definitions" by permanently deforming a flat, cast sheet <u>subsequent to the casting operation</u> using a set of heated stamping dies or carrying out the deforming step on a strip that is provided at a sufficiently elevated temperature to induce heterogeneous deformation forming shear bands in the depressions and protrusions. The advantage of using this mode of creating "articulated topological definition", as compared to Narasimhan's method, is that the <u>flatness of the sheet is preserved while maintaining a discontinuity free connection between the geometrical articulation and the amorphous metal strip</u>. The strip thickness is preserved at essentially flat articulated topographical definition, while the inclined portions of the articulated topographical

definition exhibit a slightly reduced thickness. Preservation of sheet flatness and sheet thickness at flat portions of the articulated topographical definition, in turn, makes possible the subsequent nesting of strips for producing high quality magnetic laminations or lopping off of protrusions to produce a tool. On the other hand, strips cast on a quench wheel by Narasimhan's process have essentially the curvature of the wheel superimposed thereon and contain enhanced thickness at the corners; and they cannot be effectively stacked or subject to lopping off operations.

The Narasimhan strip is an "as-cast" material. As such, it is devoid of any slip lines or shear bands. By way of contrast the "articulated topological definition" of strip delineated by applicants' claims is entirely created by <u>plastic deformation</u>, and <u>has shear bands and thus is entirely a different material identified by its metallurgical structural features</u>. The magnetic properties of plastically deformed metallic strips are distinctly different from those of as-cast material, since shear bands participate in defining magnetic domain boundaries, and alter the stress state of the laminates. The easy magnetization direction is along the shear bands. [See Amorphous Metallic Alloys Edited by F.E. Luborsky, Butterworths, 1983, pages 313-314, Roll-induced Anisotropy]. Therefore, the "articulated topological definition" required by applicants' claims allows laminated nested cores to be manufactured due to strip flatness and lack of corner-enhanced strip thickness. In addition applicants' claimed strip has unique magnetic properties, as compared to Narasimhan's strip, which is not stackable due to the inherent curvature of the strip and exhibits enhanced corner strip thickness and has inferior magnetic properties, due to being devoid of slip lines or shear bands. Accordingly, it is submitted that the Narasimhan product is <u>materially different</u> from that called for by present claims 1-4 and 6-9 in that the essential structural, geometric and magnetic properties of

the Narasimhan product differ significantly from those obtained using the strip called for by applicants' claims.

These structural elements and magnetic properties clearly distinguish claims 1-4 and 6-9, as amended, from those of conventional as-cast ribbon. Products containing the elements defined by present claims 1-4 and 6-9 are differentiated by the presence of the characteristic representing permanent deformation, for example slip bands and reduced thickness in stretched regions, and superior mechanical and magnetic properties. In addition, the production of geometrical articulations by the application of selected forces imparted by a set of stamping dies having mating surfaces, as defined by applicants' claims, results in geometrical articulation of greater magnitude than that obtained by conventional quenching processes (which lack wall angle limitations) while, at the same time, maintaining strip flatness and stackability.

Claim 1, as amended, incorporates restrictions on the stress free strip having permanent deformation and depth of the articulated topographical definition exhibiting shear bands in the articulated regions, being greater than the strip thickness produced by application of selected forces imparted by a set of stamping dies having mating surfaces to introduce permanent deformation on a generally planar previously cast amorphous strip. Claim 1 also requires that the articulated definitions have a shape and configuration that is produced without strip embrittelement or crystallization. These restrictions clearly distinguish applicants' strip from that of Narasimhan.

Accordingly, reconsideration of the rejection of Claims 1-4 and 6-9 under 35 U.S.C. 102(b) as being anticipated by US Patent 4,332,848 to Narasimhan is respectfully requested.

Claim 5 was rejected under 35 U.S.C. 103(a) as being unpatentable over Narasimhan in view of Watanabe et al. (U.S. Patent 5,622,768) or Sato et al. (U.S. Patent 4,865,664).

The Examiner has stated that Narasimhan products do not appear to contain element "Z" as defined in instant claim 5. The Watanabe or Sato et al patents indicate that it is conventional in the art to include element "Z" in amorphous alloy strip compositions, in the amounts as defined in the instant claim. Consequently, the Watanabe or Sato disclosures would have motivated one of ordinary skill in the art to produce the Narasimhan products containing an amount of element "Z" as defined in the present claims.

As noted hereinabove, the requirements of the alloy called for by claim 5 involve not only quenchability, but also the ability to create stress free ribbons with <u>permanent deformation</u> by application of forces imparted by a set of stamping dies having mating surfaces that create the geometrical articulations. Each of Narasimhan, Watanabe and Sato et al. disclose alloys having additions of element "Z" to improve quenchability; but none of these patentees disclose use of the "Z" element to provide superior <u>permanent deformability upon application of forces imparted by a set of stamping dies having mating surfaces</u>. On the other hand, the amorphous metal alloy article called for by claim 5, as amended, does <u>not cast</u> geometrically articulated amorphous metal ribbon. Instead, such ribbon is permanently deformed by forces imparted by a set of stamping dies having mating surfaces that <u>impress</u> the desired geometrical articulations which have shear bands in the articulated regions.

Accordingly, reconsideration of the rejection of Claim 5 under 35 U.S.C. 103(a) as being unpatentable over Narasimhan in view of Watanabe et al or Sato et al is respectfully requested.

Claims 11-13 were rejected under 35 U.S.C. 103(a) as being unpatentable over Narasimhan in view of either Watanabe et al. or Bruckner (U.S Patent 4,853,292).

The Examiner has recognized that Narasimhan does not discuss a plurality of stacked materials or transformer cores, as required by claims 11-13, as amended. However, the Examiner has stated that both Watanabe and Bruckner indicate it to be conventional in the art to form laminated cores by using a plurality of layers of amorphous metal alloys. Accordingly, it is the Examiner's position that these disclosures would have motivated one skilled in the art to form the materials disclosed by Narasimhan into the configurations set forth by Watanabe or Bruckner.

Narasimhan discloses as-cast material, which is geometrically articulated by having projections or depressions on a quench surface. Due to the circular or repeating nature of the quench surface <u>only periodic structures are produced</u>; such structures have at least the periodicity of the quench substrate. On the other hand, plastically deformed 3-dimensional shapes of the type required by applicants' claims 11-13, as amended, can be impressed on a permanently deformed stress free amorphous sheet in <u>completely arbitrary</u> non-periodic shapes maintaining the strip flat at the base surface while the 3-dimensional shapes impressed are devoid of enhanced corner thickness. An example of a non-periodic geometric articulation is shown in Figs. 3A and 3B of applicants' specification. On a quench chill wheel surface either depressions or projections traverse below the casting nozzle at different casting velocities compared to the general surface of the quench wheel, based on the radius at the projection or depression. Consequently, the depressions are shorter in length compared to the flat portion of the sheet, and the sheet has a curvature similar to that of the quench wheel. Forcing the amorphous ribbon to a flat shape generally tears the projections cast. In addition, the corners of the projection exhibit enhanced strip thickness due to increased contact area with the chill surface. The enhanced thickness at the corners prevents stacking of sheets with projections to produce high quality magnetic laminations. This is of course not a problem with belt

casting. Moreover, as previously noted, belt quench casting has been considered impractical, owing to fatigue failure of belt material stemming from high thermal stresses and repeated bending stresses. Such belt fatigue problems are made even more difficult when the belt carries deep depressions. Accordingly, flat sheets cast on a quench wheel are not available to produce laminations. On the other hand, permanently deformed three-dimensional shapes impressed on a planar amorphous sheet by the application of selected forces at selected process temperature imparted by a set of stamping dies having mating surfaces can be stacked to produce laminations due to the sheet's lack of fixed curvature and lack of enhanced strip thickness at the corners. The inherent nature of melt flow during a quench casting process creates severe limitations on the geometry of shapes that can be successfully replicated. This is discussed at col. 1, lines 60 through col. 2, line 17 of Narasimhan. If the angles deviate from the values disclosed by Narasimhan, reproduction of the three-dimensional pattern is not replicated. The geometrically articulated amorphous sheet disclosed by Narasimhan is full of thermal contraction stresses due to differential cooling of a complex articulation shape. Such contraction stresses compromise magnetic properties and result in non-uniform stress needed to fracture the sheet, since internal stresses are additive with applied stresses.

In order to emphasize the salient features of the present invention, claims 11-13, have been amended to require that the articulated topographical definition be produced by application of selected forces imparted by a set of mating dies having mating surfaces that introduce permanent deformation. The geometrically articulated amorphous product required by claims 11-13, as amended, is inherently different from a sheet composed of as-cast material. The problems of geometry, lack of flatness, inherent periodicity of the quench surface, and thermal contraction

stresses discussed hereinabove severely limit the application of geometrically articulated, as-cast amorphous metal sheets. In particular, the magnetic properties, cutting ability and wear resistance of as-cast amorphous metal sheets are severely compromised. The internal stress state in the Narasimhan strip is additive with respect to grinding forces, and ribbon fracture occurs at a much lower stress level. These factors differentiate the article delineated by claims 11-13, as amended, from the cited references. As a result, the geometrically articulated amorphous metal article required by claim 11-13, as amended, exhibits excellent magnetic and mechanical properties, whereas the as-cast amorphous metal alloys disclosed by Narasimhan do not.

Neither Narasimhan nor Watanabe and Bruckner disclose a permanently deformed metallic glass strip having macroscopic geometric articulation for laminated cores. Narasimhan's as-cast amorphous material is unsuitable for producing laminated cores, due to several reasons. First, the thermal contraction strains produce poor magnetic properties. Ribbon curvature, inherently produced when the ribbon is cast on a <u>quench wheel</u>, prevents stackability of as-cast, geometrically articulated amorphous metal ribbons. Even if the ribbon is quenched on a belt, the corners of geometric articulation will have enhanced strip thickness preventing stacking of sheets. This stackability problem would impair production of an article that comprises a plurality of self-nesting amorphous metal strips, as called for by applicants' claim 11. The material taught by Watanabe et al. and Bruckner has <u>microscopic</u> surface roughness (i.e. no more than .3-30 % of the strip thickness, see col. 2, lines 11-23 of Watanabe et al.), <u>not macroscopic</u> geometric articulations (i.e. greater than the strip thickness, see Figs. 2-4 of applicants' drawings), as required by claims 11-13, as amended. Since the articles produced by Watanabe et al. and Bruckner are <u>as-cast products</u>, they contain <u>thermal contraction strains</u> with <u>poor magnetic properties</u> when laminated. By way of

contrast, the article of claims 11 to 13 comprises stackable flat ribbons with geometrical articulation in a relaxed state, thereby providing a self-nesting feature not disclosed or suggested by the art applied. The amendment of claim 11, which requires that the amorphous metal strip be permanently deformed to produce an articulated topographical definition at a depth greater than the strip thickness, distinguishes the subject matter of claims 12 and 13 from the cited references. It also distinguishes the subject matter of claim 11, since geometrical articulations caused by permanent deformation have fixed dimensions each of which are greater than the strip thickness, free from edge burs and other imperfections (which are typically found in as-cast products). These features significantly improve stackability, thereby enabling articles having articulated topographical definition to be self-nesting.

For the reasons set forth above, it is submitted that combining the Narasimhan product with the laminations disclosed by Watanabe or Bruckner will, of necessity, result in a poorly stacked lamination, since the articulations would not match from strip to strip owing to the inherent curvature of an as-cast strip produced on a quench wheel. As previously noted, belt-cast material is essentially non-existent, owing to problems associated with belt material and belt thickness requirements. Large articulations have inherently increased curvature and would not result in a nested lamination, as called for by present claims 11-13. Such a nested lamination stack, and the advantageous features afforded thereby, cannot be obtained unless there is preserved the flatness condition of the strip without melt flow problems inherent to the 'as-cast' articulated strips with deep structural features produced by Narasimhan. Stacked Narasimhan strips with articulations have poor magnetic properties due to internal stresses present within these strips.

Accordingly, reconsideration of the rejection of claims 11-13 under 35 U.S.C. 103(a) as being unpatentable over the combination of Narasimhan and Watanabe et al or Bruckner is respectfully requested.

In summary, Narasimhan's material is presently produced on a quench wheel exclusively. Troublesome problems associated with belt fatigue -- even with belts devoid of protrusions or indentations -- cause <u>belt cast materials to be essentially non-existent</u>. Strips cast on a quench wheel provided with protrusions are <u>inherently non-flat</u> and <u>cannot be stacked or flattened</u>. Narasimhan's as-cast materials are devoid of slip lines or shear bands, but have <u>large internal quenching stresses</u> that reduce the strip's magnetic properties. In addition, projections and depressions created in the as-cast Narasimhan strip suffer from enhanced strip thickness at the corners thereof. These corner-located pockets of enhanced strip thickness significantly limit the ability of the strip to be stacked to produce high quality magnetic laminations. In such cases, excessive gaps between the stacked strips result in a poor stacking factor. Further, with such cases, the tips of the projections are not readily lopped off to produce an abrasive article. By way of contrast, <u>permanent deformation</u> of amorphous magnetic strips called for by applicants' claims results in slip lines or shear bands; but these slip lines <u>do not impair magnetic properties</u>. Moreover, internal stresses are absent in the plastically deformed, geometrically articulated material of applicants' claims, which is <u>completely relaxed</u>, thereby providing <u>superior magnetic properties</u>. Further, the articulated topographical definitions of applicants' claimed strip may be periodic, or non-periodic. Such articulated topographical definitions may have any shape or configuration. Still further, with applicants' claimed strip there exists a superior bond between the geometrical articulation and the base strip without the presence of the discontinuities inherently contained by Narasimhan's strip. Significantly, the geometrically

US Serial No: 09/891,033
Docket No.: 0017-40

articulated amorphous material strip delineated by applicants' claims has no restriction on wall angles of articulated topographical definitions or angular orientation of articulated topographical definitions with respect to strip length direction and are devoid of increased strip thickness at the corners of articulated topographical definitions. As a result the wall angles of articulated topographical definitions contained by applicants' claimed strip can approach 90 degrees, thereby packing a large number of articulated topographical definitions per unit area of strip, and providing a superior abrasive surface. The improved bond between geometrical articulations and absence of internal stresses in the strip called for by applicants' claims results in superior abrasive properties.

In view of the amendments to the claims and the remarks set forth above, it is submitted that this application is in allowable condition. Accordingly, reconsideration of the Final Rejection of claims 1-9 and 11-13, as amended, entry of this amendment, and allowance of the application is earnestly solicited.

Respectfully submitted,
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